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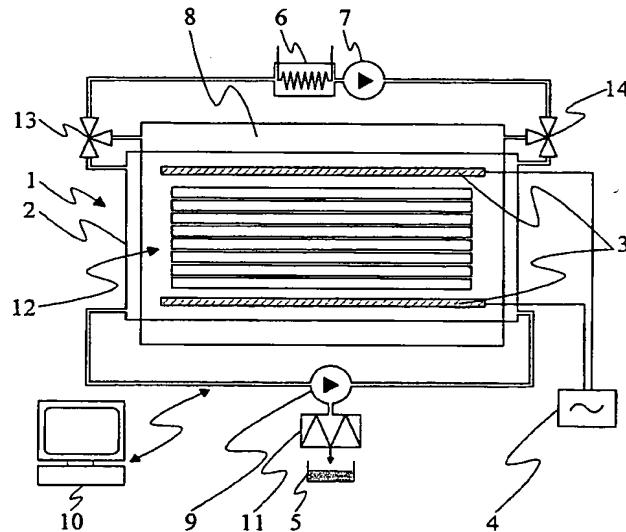
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(54) Title: METHOD AND DEVICE FOR DRYING WOOD



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(57) Abstract: The invention relates to a method and device for drying wood, in which method timber to be dried is placed in a drying chamber and dried in three phases. In the first phase, the load of timber is heated in a vacuum chamber to the desired temperature using hot water as a medium. In the second phase, water is pumped from the vacuum chamber into a surrounding container and a very low subatmospheric pressure is introduced in the vacuum chamber while at the same time heating the chamber. In the third phase, the timber is dried in a subatmospheric pressure by means of RF energy.

## Method and device for drying wood

The invention relates to a method for drying wood, in which method wood is dried in an elevated temperature using both a vacuum and RF energy in a closed drying chamber. The invention further relates to a device used in the method.

5 When processing green timber for, say, the building industry, it has to be dried or seasoned before it can be worked, i.e. sawed and planed, for example. There are several wood drying methods. Among the most common wood drying methods used today are kiln drying, vacuum drying, steaming and RF drying.

In kiln drying, stickered timber is warmed by hot air blowers in normal atmospheric pressure and the resulting water vapor is led out. In vacuum drying, timber is placed in a vacuum chamber in which the pressure is reduced to 0.2 to 0.6 bar, whereby the boiling point of water correspondingly becomes lower. Heating inside the chamber is arranged through the use of radiators and powerful fans, for example. Water vapor liberated from the wood is led out and condensed. US patent document 10 4,194,296 discloses a method in which a hot water cycle is arranged in the space surrounding the vacuum chamber, compensating for the heat loss caused by evaporated water in the chamber. In steaming, timber is heated to a temperature exceeding 15 100 °C through the use of steam blown at high speed through the timber. The steam is then led out of the drying room and drying takes place in normal atmospheric pressure.

20 Surface splitting of the wood, which often occurs in conjunction with these conventional methods, is a disadvantage. The cause of surface splitting and checking is that outer layers of wood dry quicker than inner layers, resulting in a moisture gradient too steep and, hence, splitting or distortion in the wood. The quicker the drying process, the bigger the risk of wood splitting. Similarly, a high temperature may cause degrades in the wood. Too long a drying time on the one hand may cause darkening of the wood as nutrients, which the water vapor has carried to the surface of the wood, are darkened by the heat. Too short a drying time, on the other hand, easily leaves moisture in the timber, and moisture dispersion among the timber 25 remains great.

30 In RF drying, timber is placed between two metal plates and high-frequency energy is conducted to the plates. The high-frequency energy drives the wood's water molecules into thermal movement, causing the water to heat and vaporization to accelerate. US patent document 5,103,575 teaches the use of RF energy for the final

drying of wood, but the preliminary drying takes place mainly passively through the use of the sun's heat or air drying. When using RF energy, there is the risk of excessively heating the inner parts of the wood, thus forcing the water out into the outer layers, resulting again in a moisture gradient too steep and, hence, splitting in the 5 inner parts of the wood.

Combined RF and vacuum drying has also been tried. Patent documents WO 9918401 and US 2,387,595, for instance, disclose methods in which a vacuum chamber includes a means of conducting RF energy into the timber. The use of RF energy is, however, expensive because the efficiency of the RF generator is poor, 10 only about 50%. Especially in the case of frozen timber, RF energy has been too expensive to use for drying.

Patent document SU 511492 discloses a method in which the temperature of a bundled load of timber is raised by immersing it for 10 to 30 minutes in boiling water in a special tank prior to being transferred to a drying kiln.

15 Many problems, such as drying defects, will be encountered in wood drying. The most common defects include splitting and warping. Boiling of resins and loosened knots may be caused by temperatures too high. Some species of wood, like birch, are easily darkened. That may be caused by too high a temperature, a long drying time or oxidation, for example. Timber drying defects result in great financial losses 20 every year. However, the industries that use dried timber, such as e.g. the furniture industry, demand a very high quality and degree of dryness of the timber they use. With conventional methods it has been possible to achieve high and even quality only through the use of very slow drying times in order to avoid wood splitting, 25 warping and darkening during the drying process. This, in turn, calls for long timber storing times, tying up a lot of industry capital and being difficult to arrange because of the short turnover times that are common today.

As green or wet lumber is a good thermal conductor, heat can be easily conducted 30 into the wood. However, as the wood dries, it becomes a good thermal insulator, whereby it becomes extremely difficult to conduct heat into the wood. This lengthens the drying time. In addition, it has been practically impossible to dry certain types of wood with the known methods. Examples of such types of wood 35 include massive logs and whole tree trunks, used by log house builders and pole manufacturers, for example. Furthermore, certain species of tree, such as species of birch and many hardwood species, like oak, beech and similar close-grained tree species, are hard to dry. Moreover, one problem in winter, especially in northern

countries, is that the timber may be frozen, depending on the storage conditions and time of cutting, whereby a need has arisen for a quicker and more efficient drying method. Another problem is the energy wasted in the drying process. In practice, only a fraction of the energy used is directed to driving the water out of the wood,

5 and thermal energy easily escapes kilns. Long drying processes also consume very much energy.

An object of this invention is to provide a novel drying method and device for drying wood, said method minimizing drying defects and drying times, and said device consuming little energy and being a packet solution easily applicable industrially.

10 The objects of the invention are achieved by a device arrangement in which timber is placed in a drying chamber and the phases of drying take place in a single confined space.

The method and device according to the invention are characterized in that which is specified in the respective independent claims. Some preferred embodiments of the 15 invention are specified in the dependent claims.

The invention combines three methods, which are known as such, into a single three-phase method. Thus there is provided a novel drying method the drying result of which is considerably better than that of any one of the individual methods as regards both speed and quality and energy consumption. This is because each phase 20 is optimized according to the current degree of dryness and state of the timber, and there are no unnecessary phases that would consume extra energy. In the prior art, optimization has been mainly directed to individual methods in order to get the best result, and not enough attention has been paid to the speed of drying while at the same time maintaining high quality. In part this is the result of the fact that in most 25 countries the timber is never frozen and, because of climatic conditions, wood dries reasonably well already during storage.

The idea of the invention is basically as follows: timber to be dried is placed in a drying chamber and dried in three phases. In the first phase, the load of timber is heated in a vacuum chamber to a desired temperature using hot water as a medium. 30 As the wood warms up in a moist environment, there will not occur internal stresses between the inner and outer parts of the timber and, hence, no splitting, which easily occurs while pre-heating timber in dry conditions.

In the second phase, water is pumped out of the vacuum chamber into a surrounding container, and a very low subatmospheric pressure is introduced in the vacuum

chamber while simultaneously heating the chamber. The internal pressure in the wood is now higher than in the chamber, which drives free water out of the wood. Water is vaporized in the vacuum chamber and removed via a condenser. The walls of the vacuum chamber release thermal energy into the chamber and into the surface  
5 of the wood to compensate for the energy removed from the wood. The moisture content of the wood drops steeply at this stage.

In the third phase, the wood has become a good thermal insulator and it is not any more easy to drive external thermal energy into the wood through heating the chamber. At this point, RF heating is turned on, which induces intense thermal  
10 movement in the water inside the wood. The internal temperature of the wood can be now set to the desired level in order to maintain the pressure difference which drives the water out of the wood.

An advantage of the invention is that even completely frozen timber and massive logs can be quickly and thoroughly dried on an industrial scale and the drying  
15 capacity is large.

Another advantage of the invention is that drying defects, such as splitting, warping and darkening of the wood, can be minimized.

A further advantage of the invention is that the energy consumption is low, a cheap source of energy can be used, and, because of effective energy re-use, little energy  
20 is lost.

A yet further advantage of the invention is that the whole apparatus constitutes a compact "packet solution" which can be delivered to the customer by lorry, requiring only a little installation work at the customer's end.

A still further advantage of the invention is that the whole process can be controlled  
25 using a computer program.

The invention will be described in detail in the following. Reference will be made to the accompanying drawing in which

Fig. 1 schematically depicts a device arrangement according to the invention.

Fig. 1 schematically shows, by way of example, a preferred device arrangement  
30 according to the invention. The device 1 includes a vacuum-proof, hermetically sealed, elongated drying chamber 2 in which timber 12 is inserted for drying. The chamber 2 can be opened and closed at both ends or at one end for the insertion of

timber 12. In the first drying phase, a hot water cycle is arranged in the chamber 2 by means of a water cycling system comprising a water heater 6, water pump 7 and control valves 13, 14 for controlling the flow of water, and a thermally insulated water container 8 which surrounds the vacuum chamber 2 at all places except the 5 ends. The control valves 13, 14 are used to direct the hot water into the drying chamber 2 where the timber 12 to be dried is located. The water heater 6 works on external energy, advantageously electric energy or thermal energy generated by burning wood bark or chips, for example. The continuously heated cycling hot water effectively releases its thermal energy into the timber 12. The viscosity of the 10 water in the wood is changed such that the water, under pressure, easily comes out of the wood. Frozen timber or a wet massive log will reach the desired temperature in two to three hours.

The second drying phase begins when the load of timber 12 has reached the desired 15 temperature, say 80 to 90 °C. In this phase, the water is pumped through the pump 7 and control valves 13, 14 from the vacuum chamber 2 into the surrounding water container 8, and a subatmospheric pressure, say about 0.05 bar, is introduced in the drying chamber 2 by means of a vacuum pump 9. The heat of the hot water cycling in the water container 8, advantageously at about 100 °C, heats the walls of the vacuum chamber 2 as well as the timber 12 therein, and the water vapor generated 20 as the wood dries is condensed in a condenser 11, and the distillate 5 is removed from the system. Water cycling in the water container 8 is continuously heated by the water heater 6. At this stage, the moisture content of the wood drops steeply, i.e. from completely wet to less than 20%.

In the third drying phase, when the surface layer of the timber 12 has dried and has 25 become a good thermal insulator and, therefore, as there is no sense in continuing the drying process through the use of external thermal energy, high-frequency energy is turned on. On the inner sides of the vacuum chamber 2 there are electrodes 3, advantageously metal plates, into which RF energy is conducted by means of a RF generator 4 so that said RF energy causes thermal movement in the water 30 inside the timber 12 between the electrodes 3. Warm water within the wood is easily vaporized in the vacuum and it is removed from the drying chamber 2 via the condenser 11. RF drying continues until the desired moisture content has been achieved. Generally it is easy to reach a moisture content of less than 8%, i.e. timber fit for building and joinery, without defects. The operation of the device 1 according 35 to the invention is controlled by a control unit 10 which advantageously may be a computer with a program or software controlling the functioning of the system

components such as the water pump 7, water heater 6, cycling of water in the vacuum chamber 2 and water container 8 through the control valves 13, 14, vacuum pump 9, condenser 11, and removal of the distillate 5 from the system, as well as the use of RF energy by means of the RF generator 4 and RF-energy-emitting electrodes 3, or just part of these. The control unit 10 may also be a dedicated, embedded system or a discrete control panel, for example.

Above I have described a few preferred embodiments according to the invention. The invention is not limited to the solutions described above. For example, the external energy used for the heating of water may also come from other sources.

10 The invention idea can be applied in numerous ways within the scope defined by the attached claims.

## Claims

1. A method for drying wood (12), in which method wood is dried in an elevated temperature in a closed drying chamber (2) using a vacuum and RF energy, characterized in that prior to vacuum drying the temperature of the timber (12) is raised in the drying chamber (2) to the desired level using hot, advantageously boiling, water as a medium.  
5
2. A method according to claim 1, characterized in that the drying of wood takes place in one and the same drying chamber (2) in three consecutive phases, where the temperature of wood is raised in the first phase by means of hot water to 10 the desired level and, in the second phase, the water is removed from the drying chamber (2) and a subatmospheric pressure is introduced in the chamber and wood is heated by heating the chamber and, in the third phase, a subatmospheric pressure is maintained in the chamber (2) and wood is heated using RF energy.
3. A method according to claim 1, characterized in that the timber (12) to be 15 dried is heated by hot water such that it reaches a temperature of about 80 to 90 °C.
4. A method according to claim 1, characterized in that the subatmospheric pressure introduced in the drying chamber (2) is about 0.05 to 0.1 bar.
5. A method according to claim 1, characterized in that water that was used in 20 the heating of timber (12) is used during vacuum drying to heat the drying chamber (2).
6. A method according to claim 1, characterized in that when RF energy based drying is started, the moisture content of the timber (12) is about 20%.
7. A wood drying device (1) with a vacuum chamber (2) for drying timber (12) by means of a subatmospheric pressure and means 3 for conducting (3) RF energy 25 into the timber (12), characterized in that the device further comprises means of heating (6) water and conducting (7, 8, 13, 14) heated water into and out of the vacuum chamber (2).
8. A wood drying device (1) according to claim 7, characterized in that said means comprise a water container (8) placed so as to surround the drying chamber (2) in order to raise the temperature of the chamber by means of heated water.  
30
9. A wood drying device (1) according to claim 7, characterized in that the device comprises a control system (10) for controlling the drying process.

10. A control system (10) according to claim 9, **characterized** in that the control system (10) comprises a computer and a computer program or software for controlling a wood drying device (1).
11. A wood drying device (1) according to claim 7, **characterized** in that the device can be assembled so as to constitute an easy-to-move and easy-to-set-up package.

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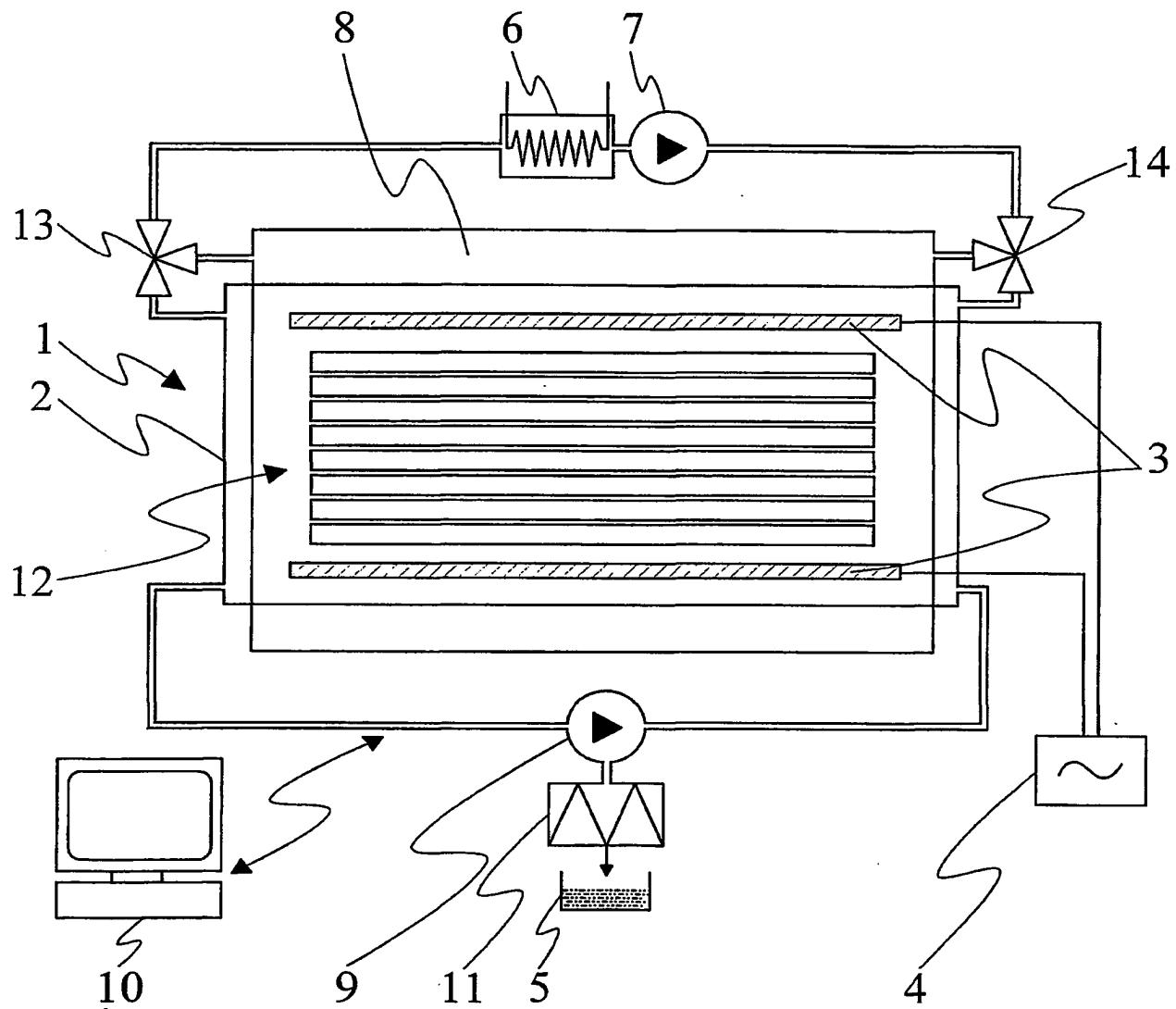


Fig. 1

## INTERNATIONAL SEARCH REPORT

International application No.

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## A. CLASSIFICATION OF SUBJECT MATTER

IPC7: F26B 5/04, F26B 3/347

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC7: F26B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

## WPI DATA, EPO-INTERNAL, PAJ

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 9918401 A1 (WOLF SYSTEMBAU GESELLSCHAFT M.B.H.), 15 April 1999 (15.04.99) --	1-11
X	US 2387595 A (H.J. LUTH ET AL), 23 October 1945 (23.10.45) --	1-11
A	WPI/Derwent's abstract, Accession Number 1979-D7365B, week197917, ABSTRACT OF SU 511492 A (DONSKOV S V ) 31 August 1976 (31.08.76) --	1,2,7
A	US 5103575 A (KUNIHARU YOKOO ET AL), 14 April 1992 (14.04.92) --	6

 Further documents are listed in the continuation of Box C. See patent family annex.

\* Special categories of cited documents:

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"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

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**INTERNATIONAL SEARCH REPORT**International application No.  
**PCT/FI 02/00097****C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT**

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 4194296 A (VINCENZO PAGNOZZI ET AL), 25 March 1980 (25.03.80)  --- -----	5,8

**INTERNATIONAL SEARCH REPORT**

Information on patent family members

28/01/02

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Patent document cited in search report	Publication date	Patent family member(s)		Publication date
WO 9918401 A1	15/04/99	AT	169997 A	15/05/01
		AT	408575 B	25/01/02
		EP	0950163 A	20/10/99
US 2387595 A	23/10/45	NONE		
US 5103575 A	14/04/92	CA	2035715 A	06/08/91
		JP	1930483 C	12/05/95
		JP	3230902 A	14/10/91
		JP	6049283 B	29/06/94
US 4194296 A	25/03/80	CA	1110445 A	13/10/81
		DE	2821259 A,C	23/11/78
		FR	2391438 A,B	15/12/78
		IT	1083106 B	- 21/05/85
		JP	1147390 C	26/05/83
		JP	53141973 A	11/12/78
		JP	57035387 B	28/07/82

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